EFFECT OF NEUROMUSCULAR ELECTRICAL STIMULATION AND MOTOR ACTIVITY ELICITING EXERCISES IN EARLY SHOULDER REHABILITATION AMONG BRUNNSTROM'S STAGE - I HEMIPLEGICS

- AN EXPERIMENTAL STUDY

Dissertation submitted to The Tamil Nadu Dr. M.G.R. Medical University towards partial fulfilment of the requirements of **MASTER OF PHYSIOTHERAPY (Advanced PT in Neurology)** Degree programme.

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CERTIFICATE

This is to certify that the research work entitled "**EFFECT OF NEUROMUSCULAR ELECTRICAL STIMULATION AND MOTOR ACTIVITY ELICITING EXERCISES IN EARLY SHOULDER REHABILITATION AMONG BRUNNSTROM'S STAGE - I HEMIPLEGICS- AN EXPERIMENTAL STUDY",** was carried out by the candidate bearing the **Register No. 27091611,** KMCH College of Physiotherapy, towards partial fulfilment of the requirements of The Master of Physiotherapy (MPT) degree course under The Tamilnadu Dr. M.G.R. Medical University, Chennai – 32.

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CONTENTS

ABSTRACT

BACKGROUND AND PURPOSE: Shoulder subluxation is a most significant problem in post stroke hemiplegics, resulting in pain and loss of function. Surface electrical stimulation was found to reduce existing subluxation, but showed no significant improvement in motor function. The main purpose of this study was to determine the short term effects of neuromuscular electrical stimulation and motor activity eliciting exercises in preventing the occurrence of shoulder pain and subluxation and in enhancing early shoulder mobility. **STUDY DESIGN:** Two groups' pre test – post test experimental study design. **PARTICIPANTS:** 16 acute stroke patients (upto 2 weeks) involving MCA of both sexes between 40 and 80 years with no history of shoulder pain and subluxation. **INTERVENTION:** 16 patients are randomly assigned to a control or experimental group, 8 in each. They had their first assessment within 48 hours of their stroke. The experimental group received electrical stimulation for half an hour per session, twice a day for a week and also they are given motor activity eliciting exercises for another half an hour. The control group received Bobath based exercises. All patients are assessed a week after treatment. **OUTCOME MEASURES:** The shoulder pain was assessed by Numeric pain Rating Scale (NRS); shoulder motor function by the Fugl - Meyer assessment (FMA - shoulder component) scale.

RESULTS: At baseline, patients in both groups are similar. After the intervention, the treatment group showed significant effect in preventing the occurrence of shoulder pain and subluxation and also showed significant improvement in shoulder motor function. **CONCLUSION:** Neuromuscular electrical stimulation (NMES) and motor activity eliciting exercises have short term effect in preventing the occurrence of post stroke shoulder pain and subluxation and also in improving shoulder motor function.

Key words: Hemiplegic shoulder pain, neuromuscular electrical stimulation, facilitation exercises for flaccid shoulder.

1. INTRODUCTION

Stroke or brain attack is the sudden loss of neurological function caused by an interruption of the blood flow to the brain. Stroke is defined by World Health Organization (**WHO)** as “a rapidly developing syndrome with clinical signs of focal or global disturbance of cerebral function with symptoms lasting for 24 hrs/longer or leading to death, with no apparent cause other than vascular origin”.[100]

Patients with acute stroke are vulnerable to various complications, among which the most common are shoulder pain and subluxation. Shoulder pain can result in significant disability that can limit the patients’ ability to reach their maximum functional potential and impede rehabilitation.[70]

Shoulder pain can negatively affect rehabilitation outcomes because good shoulder function is a pre-requisite for successful transfers, maintaining balance, performing activities of daily living and for effective hand function.[78] Estimates of the prevalence of post stroke shoulder pain vary widely from 16 to 80%.There are many contributing factors for hemiplegic shoulder pain. They include subluxation, brachial plexus injury[21], rotator – cuff tear[64], and capsulitis. Shoulder subluxation has been proposed to be a most common contributing factor in the development of shoulder pain. As many as 80% of patients with hemiplegia have been reported to demonstrate a shoulder subluxation.[64]The incidence of shoulder subluxation varies greatly from 17 to 81%.[80]

Shoulder subluxation is defined as "changes in the mechanical integrity of the glenohumeral joint causing a palpable gap between the acromion and humeral head". Glenohumeral joint malalignment and subluxation are reported to occur in patients with little or no voluntary movement after stroke.[64] The vulnerability of the glenohumeral joint to subluxation is a function of the anatomy of the joint. As shoulder joint is an extremely mobile joint, it sacrifices stability for mobility.[14]

GLENOHUMERAL JOINT:

- It is a ball and socket type of synovial joint, formed by the articulation of glenoid cavity of scapula and head of humerus.
- The thin and lax joint capsule is attached to the margin of glenoid labrum proximally and to the neck of humerus distally. The capsule is reinforced by glenohumeral and coracohumeral ligaments.
- The ligaments around the glenohumeral joint are so loosely attached so that head can be distracted 2 cm outward with the arm by the side.[66]
- The glenohumeral joint relies on the integrity of muscular (supraspinatus, deltoid, latissimus) and capsuloligamentous structures rather than bony confirmation for its stability.[58]
- The main stabilizing muscles of glenohumeral joint in dependant arm are supraspinatus and deltoid.

PATHOKINESIOLOGY:

- The supraspinatus helps to stabilize the glenohumeral joint by exerting a horizontal pull to hold the humeral head against the glenoid process. Although the deltoid muscle is well aligned to prevent the descent of the humeral head from the glenoid fossa in quite standing, some individuals show no activity in deltoid in upright posture. In contrast, the supraspinatus in some individuals exhibits EMG activity during erect standing, particularly as the upper extremity is pulled inferiorly by a weight in the hand.
- The proposed function of the supraspinatus in preventing the inferior subluxation of the glenohumeral joint is facilitated by the upward tilt of the glenoid fossa.[15]
- Although supraspinatus may not be active when the arm is hanging at the side, paralysis or dysfunction in the supraspinatus may lead to gradual inferior subluxation of the glenohumeral joint. Without the reinforcing passive tension of the intact supraspinatus, the sustained load on the structures of the rotator interval capsule apparently causes these structures to gradually stretch (become plastic), which results in a loss of joint stability.[66]
- After cerebral infarction, patients go through a period of flaccidity along with loss of volitional motor activity, variable sensory loss, and loss of

muscle stretch reflexes. It is during this period that, if unsupported, the weight of the arm will stretch the surrounding muscle cuff and distend the joint capsule, resulting in inferior subluxation of the humerus.[37]

- Affected upper extremity becomes flaccid in approximately 90% of the patients.[71]
- Muscular support of the head of the humerus in the glenoid fossa by the supraspinatus and deltoid muscles is lost, which leads to downward and outward subluxation of the humeral head.[82]
- Improper positioning in bed and lack of support while the patient is in upright position or pulling on the hemiplegic arm when transferring the patient all contribute to glenohumeral subluxation. The resulting mechanical effect is over stretching of the glenohumeral capsule and flaccid supraspinatus and deltoid muscles with increase in the risk of injury and pain.[6,86]

Glenohumeral subluxation can be considered one of several potential sources of hemiplegic shoulder pain, it can be present alone or together with other problems, and it should be treated early after stroke.[58]

Glenohumeral subluxation is a factor that is associated with shoulder pain development and with arm motor recovery and should be treated in the acute stage of hemiplegia.[59]

1.1. NEED FOR THE STUDY

Shoulder pain is the most common complication associated with hemiplegia and has the potential to delay rehabilitation as the painful joint may mask improvement in motor function.[68] Glenohumeral subluxation is defined as a partial or incomplete dislocation that usually stems from changes in the mechanical integrity of the joint. Glenohumeral joint subluxation is a common problem in patients with hemiplegia, especially during the flaccidity stage, and often within 3 weeks post stroke.[80]

It has long been assumed that if not corrected, a pattern of traction on the flaccid shoulder will result in pain, decreased range of motion and contracture.[37]A common sequelae of stroke is hemiplegic shoulder pain that can hamper functional recovery and subsequently will lead to disability.[80] Anderson suggested that stretching of the joint capsule should be avoided during the flaccid phase. This shows that preventing shoulder subluxation in the flaccid phase is important.[4]

Traditionally, slings are applied to prevent or reduce shoulder subluxation after stroke. The most effective slings existing have the drawback of holding the limb in a poor position that is likely to cause soft tissue contracture and have a disadvantageous effect on symmetry, balance, and body image.[7, 11, 16] To date, the only treatment option for post stroke shoulder dysfunction supported by RCTs is surface neuromuscular stimulation which has been to reduce shoulder subluxation and improve pain free range of motion.[27] Clinical reports have suggested that electrical stimulation can improve muscle strength, joint malalignment, muscle tone, sensory deficits, pain free range of passive humeral lateral rotation and self reported pain intensity.[6,37, 69]

The preventive treatments should begin as soon as possible, usually within 1-2 days post stroke. Recently electrical stimulation has been applied for the shoulder muscles in the aim of preventing and also for reducing shoulder subluxation and pain in acute hemiplegic patients.[5, 21, 35,49] The previous studies suggested the effectiveness of electrical stimulation for the treatment, but there are fewer studies on the prevention of shoulder subluxation in the flaccid phase using a cross over design.[50] The electrical stimulation reduced the severity of glenohumeral subluxation but there was no significant effect on upper limb motor recovery.[69] There needs also active exercises to elicit and strengthen muscle activity and gain optimal motor control of the limb, the experimental group was added shoulder motor activity eliciting exercises. Muscle activity is frequently present under right conditions, even in an apparently flaccid limb.[15]

The aim of this study is to analyze the effectiveness of neuromuscular electrical stimulation along with motor activity eliciting exercises immediately after stroke to prevent the occurrence of post stroke shoulder pain and subluxation among Brunnstrom’s first stage hemiplegic patients and to promote early shoulder motor recovery.

1. REVIEW OF LITERATURE

2.1. Biomechanics of a normal shoulder:

- ✓ **Basmajian JV, Bazant FJ (1959):** In quite, relaxed standing, no muscular activity is found in EMG analysis. But, there occurs a strong contraction in supraspinatus and weak reaction in the posterior deltoid, when there is any downward tug in the arm or any weight in the arm.[5]
- ✓ **Basmajian JV, Deluca CJ:** They said that, "although the deltoid is well aligned to prevent descent of the humeral head, some individuals show no activity in the deltoid in upright posture. In contrast, the supraspinatus in same individuals exhibits EMG activity during erect standing, particularly as the upper extremity is pulled inferiorly by a weight in the hand. The supraspinatus helps stabilize the Glenohumeral joint by exerting a horizontal pull to hold the humeral head against the glenoid fossa.[15]

1.2. Hemiplegic shoulder pain and subluxation:

- ✓ **J.S. Tobis (1957)** suggested that the main cause of shoulder pain in hemiplegia was due to the weight of a flaccid upper extremity stretching the ligaments and soft tissues thus causing subluxation and pain.[94]
- ✓ **Miglietta et al., (1959)** reported an incidence of inferior subluxation of 56% in their series of 50 hemiplegic patients and observed that subluxation is usually apparent clinically in sitting or standing position.

They found inverse relation between subluxation and the degree of arm function (22/28 patients demonstrated no active shoulder motion).[62]

- ✓ **Najenson and Pikienly (1966)** reported a 66% incidence of shoulder malalignment in 104 cases of complete/severe hemiplegia and also demonstrated that with lesser degree of paralysis or only paresis, subluxation occurs less commonly (16%).[63]
- ✓ **RS Smith et al.(1982),** used radiograph in his study and found 46 patients presented with complete paralysis of the arm, of whom 28 showed shoulder malalignment.[88]
- ✓ **Shai et al. (1984),** 33 patients received at least a single radiograph early in their hospitalization. Clinical status was assessed 4 to 11 months after stroke. There was a significant correlation between abnormal radiologic findings early in the course of stroke and the development of pain. 19/33 patients had evidence of subluxation on radiograph and 17/33 had shoulder pain. Of those with shoulder pain 14/17 (82%) had subluxed shoulders.[87]
- ✓ **Van Langenberghe HV, Hogan BM (1988),** found subluxation in 24 out of 44 patients (54.5%) and said no statistically significant difference was found in the degree of pain between patients with and without subluxation.[96]

- ✓ **Boyd EA et al., (1993),** reported that 72 hemiplegic patients are examined, out of whom 36 patients had a shoulder subluxation, giving an incidence of 50%.[9]

- ✓ **Gamble et al. (2000),** 182 unselected, consecutive patients admitted to hospital and assessed for pain within 2 weeks of stroke. Pain was assessed using a visual analog scale. 31(25%) reported shoulder pain.[38]

- ✓ **Giles E Gambel et al., (2002),** in his study with 123 hemiplegic patients concluded that shoulder pain after stroke is much more common than previously mentioned, affecting 40% of patients. It tends to occur within 2 weeks of the cerebral event and also shown that shoulder pain is predominantly an early association of rehabilitation. Over half of the patient reported shoulder pain in the first 2 weeks.[39]

- ✓ **Daviet JC et al., (2002),** found that shoulder subluxation was observed in 32% of hemiplegic patients.[29]

- ✓ **Turner-Stokes L, Jackson D (2002)** found that in the flaccid stage, the shoulder is prone to inferior subluxation and vulnerable to soft-tissue damage. The arm should be supported all times and functional electrical stimulation may reduce subluxation and enhance return of muscle activity.[95]

- ✓ **Lo et al. (2003)**, 32 consecutive patients with shoulder pain following stroke are assessed for shoulder subluxation, which was diagnosed by a gap of more than one finger breadth between the acromion and the head of the humeral bone on palpation. 14 (44%) of patients had clinically diagnosed shoulder subluxation.[56]

- ✓ **Aras MD et al., (2004)** did a study with 85 consecutive hemiplegic patients in Turkey to identify the incidence of shoulder pain and found 27 patients developed glenohumeral joint subluxation and reported shoulder pain, compared to 5 patients with the same finding, but without pain after stroke.[4]

- ✓ **Matteo Pauci et al., (2005)** did a study in an overview on hemiplegic shoulder subluxation and concluded that glenohumeral subluxation can be considered as one of several potential sources of shoulder pain, it can be present alone or together with other problems, and it should be always treated early after stroke onset.[58]
- ✓ **Karen L et al., (2005),** said that approximately 84% of all stroke patients will experience shoulder subluxation and pain and suggested gentle range of motion and functional electrical stimulation may reduce and prevent shoulder subluxation and pain.[28]
- ✓ **Matteo Paci et al., (2006),** conducted a case control study with a sample of 107 hemiplegic adults with recent stroke (less than 30 days from

onset). Motor recovery in their study was assessed using the upper extremity part of the Fugl-Meyer Assessment Scale and the presence of shoulder pain was recorded at admission, at discharge and at follow-up, 30-40 days after discharge. Glenohumeral subluxation was present in 52 patients (48.6%) and correlated significantly to shoulder pain and was independently associated with the upper extremity score of the Fugl-Meyer Assessment Scale at follow-up (adjusted $R^2 = 0.766$; $p < 0.001$).

He concluded that glenohumeral subluxation is a factor associated with shoulder pain development and with arm motor recovery and should be treated in the acute stage of hemiplegia.[59]

- ✓ **Ingrid Lindgren et al., (2007)**, did a study regarding post stroke shoulder pain with 307 patients. All patients undergone 2 follow ups (one after 4 months and another after 6 months). He found that one third of patients developed shoulder pain (23% after 6 months and 22% after 4 months).[45]

- ✓ **Dromerick et al. (2008),** 46 consecutive stroke rehabilitation inpatients are examined prospectively within 2 weeks of admission. Pain was self-reported in 17 (37%), 7 with pre-existing pain.[34]

- ✓ **Ramazan KIZIL et al., (2009),** the frequency of shoulder pain in 38 hemiplegic patients was 50%. In most of the patients (84%), shoulder pain occurred in first 8 weeks. They concluded that complete plegia at the beginning and shoulder subluxation seem to be related factors in hemiplegic shoulder pain. In stroke patients, all the measures for prevention and early rehabilitation should be started.[78]

- ✓ **Kumar et al., (2009),** they reviewed the literatures related to post stroke shoulder subluxation and its complications. They found that, although the association between subluxation and post-stroke complications is uncertain, when present in combination, these complications could have a significant impact on upper limb function. Early rehabilitation programmes which targeted shoulder muscle function may be the best approach to the prevention of secondary complications and the facilitation of motor recovery in the upper limb.[52]

1.3. Impact of Painful Hemiplegic Shoulder on Function

- ✓ **Roy et al. (1995)** did a study with 76 patients suffering first stroke. Shoulder pain on movement was associated with increased length of hospital stay, poorer performance on ADL, arm function and arm power. Shoulder pain was a statistically significant predictor of arm function.[83]

- ✓ **Wankyln et al. 1996** studied with 108 stroke patients and found 63.8% of all patients developed hemiplegic shoulder pain (HSP). HSP was associated with reduced shoulder shrug and reduced pinch grip. Patients who required assistance with transfer are more likely to suffer with HSP.[97]

- ✓ **Ratnasabapathy et al. (2003)** did a population based study of 1,761 stroke survivors and found in those surviving to six months after stroke, the risk of shoulder pain increased with severity of upper limb motor deficit; mild (Odds Ratio (OR)= 2.46), moderate (OR 3.64) and severe (OR 4.94).[79]

- ✓ **Robert Teasell MD (2009):** The development of painful hemiplegic shoulder is associated with severe strokes and poorer functional outcome.[81]
- ✓ **Rachael Lowe (2010)** reviewed 8 articles and found complete loss of motor function/severity of arm paralysis, apparent absence of supraspinatus contraction, sensory impairment, loss of proprioception and hemorrhagic type of stroke are identified as potential risk factors.[81]
- ✓ **Melissa Muller (2010):** Implications of pain in hemiplegia are increased length of hospital stay, decrease in Fugl – Meyer Assessment levels, increases the complication of the rehabilitation process, is correlated to depression and decreased QOL, is related to decreased movement and activity, negative impact on functional outcomes, related to poor arm recovery after CVA, poor rates of discharge to home.[61]

1.4. Management of hemiplegic shoulder:

- ✓ **Inaba et al. (1972),** in RCT 33 patients with hemiplegia who experienced shoulder pain in the range of 0-90 degrees of flexion or abduction of the arm after stroke are treated. Patients are randomly assigned to 1 of 3 groups: Range of motion (ROM) exercises and positioning group; ROM exercises and ultrasound; or ROM exercises and mock ultrasound. All patients received ROM exercises for 4 weeks and given a minimum of 15 treatments. No significant differences between the groups are observed in measures of ROM.[44]

- ✓ **Hurd et al. (1974)** 14 patients are alternately assigned to be treated with a sling or without a sling, assessed 2 to 3 weeks and 3 to 7 months post stroke. Of the 7 patients without slings, 5 had no pain, while 2 had little pain. Of the 7 patients treated with slings, 6 had little pain, while 1 had no pain.[43]

- ✓ **Kumar et al. (1990)** in his study, applied 3 exercise programs: 1. ROM by the therapist; 2. Skate board; 3. Overhead pulley with 48 hemiplegic patients found that overhead pullies caused dramatically higher levels of shoulder pain than more restrained ROM exercises.[61]

- ✓ **Leandri *et al (1990)*** evaluated the effectiveness of high intensity versus low intensity transcutaneous electrical nerve stimulation (TENS) versus placebo for patients with hemiplegic shoulder pain. The researchers found that patients who received high intensity TENS had significant improvements in passive range of motion for flexion, extension, abduction, and external rotation at the shoulder. The patients receiving high intensity TENS also reported very satisfactory pain relief.[55]

- ✓ **Patridge et al. (1990)** in an RCT 65 patients are randomized to receive cryotherapy or Bobath therapy daily for five days and then after at the therapist's discretion for a total of four additional weeks and assessed by a blinded investigator. A greater proportion of patients treated by the Bobath method reported no pain or only occasional pain on exit of the study compared to those treated by the cryotherapy method.[68]

- ✓ **Brooke MM et al., (1991),** compared the effects 3 different supports for subluxation and found Harris hemi sling gave good vertical correction of subluxation; the Bobath sling did not correct the subluxation as well; the arm trough/lap board was less effective and tended to overcorrect. These results highly support the effectiveness and specificity of shoulder support to reduce subluxation after hemiplegia.[11]

- ✓ **Ancliffe (1992)** did a pilot study of 8 patients who are assigned to receive strapping of the shoulder applied by one physiotherapist and changed every 3 to 4 days. Treatment began within 48 hours of admission to hospital. Patients in the strapping group experienced a significantly longer pain free period than the patients who are not strapped (21 vs. 5.5 days). However, all patients in the strapping group eventually did experience pain. The longest pain-free period was 25 days.[2]

- ✓ **Braus *et al (1994)*,** investigated the efficacy of an information and education programme in the prevention of hemiplegic shoulder pain. The researchers found that awareness of potential injuries to the structures of the shoulder joint reduced the frequency of shoulder pain from 27% to 8%. The researchers found that awareness of potential injuries to the structures of the shoulder joint reduced the frequency of shoulder pain from 27% to 8%.[10]

- ✓ **Zorowitz et al. (1995)** An occupational therapist applied each shoulder support to each of 20 patients in the following order: (1) single-strap hemisling; (2) Rolyan humeral cuff sling; (3) Bobath roll; and (4) Cavalier support. The single-strap hemisling corrected vertical displacement, while the Roylan and Bobath roll significantly reduced vertical displacement. The Bobath roll and the Cavalier support produced a significant lateral displacement of the humeral head of the affected shoulder compared with the unaffected shoulder. The Roylan humeral cuff sling significantly decreased the total subluxation asymmetry.[105]

- ✓ **Linn SL, Granat MH, Lees KR (1999):** traditionally, slings have been applied to prevent/reduce shoulder subluxation after stroke. The most effective slings has the drawback of holding the limb in a poor position that is likely to cause soft tissue contracture and have a disadvantageous effect on symmetry, balance, and body image.[55]

- ✓ **Dr Kieran Walsh (2001)** Careful positioning and handling of the limb are thought to prevent hemiplegic shoulder pain, but there is a range of opinions about how correct limb positioning is best achieved.[98]

- ✓ **Griffin & Bernhardt (2006)** in an RCT, 33 patients at risk of developing hemiplegic shoulder pain are randomized to therapeutic shoulder (TS) strapping, sham shoulder (SS) strapping or to a no strapping (control) group 10 days post stroke. The difference was statistically significant for the comparison of TS and control group. There is no difference found between groups on any of the secondary outcomes.[41]

- ✓ **Robert Teasell MD (2009):** There is consensus (Level 3) opinion that proper positioning of the hemiplegic shoulder helps to avoid subluxation. However, there is conflicting (Level 4) evidence that prolonged positioning prevents loss of active or passive range of motion, or reduces pain.

  There is limited (Level 2) evidence that shoulder slings prevent subluxation associated with hemiplegic shoulder pain, although there is also limited (Level 2) evidence that one device or method is no better than another.

  There is conflicting (Level 4) evidence that strapping the hemiplegic shoulder reduces the development of pain. There is moderate (Level 1b) evidence that strapping does not improve upper limb function or range of motion.

There is limited (Level 2) evidence that providing an oral nonsteriodal anti-inflammatory drug leads to less pain, improved range of motion and improved functional recovery in stroke patients with shoulder pain receiving physical therapy.

There is moderate (Level 1b) evidence that static positional stretches performed daily during rehabilitation are associated with increasing pain and decreasing range of motion.

There is moderate (Level 1b) evidence that aggressive range of motion therapies, using overhead pullies results in increased rates of shoulder pain.

There is moderate (Level 1b) evidence that Bobath therapy for the hemiplegic shoulder is associated with greater pain reduction than passive cryotherapy (application of local cold therapy).

There is moderate (Level 1b) evidence that gentle exercises to improve range of motion are the preferred approach.

There is moderate (Level 1b) evidence that adding ultrasound therapy to range of motion exercises does not change outcomes.

There is conflicting (Level 4) evidence that functional electrical stimulation reduces pain, improves function and reduces subluxation following stroke.[81]

1.5. NMES and motor activity eliciting activities:

- ✓ **Judy W. Griffin (1986)** reviewed the literatures relevant to possible causes, prevention and treatment of hemiplegic shoulder pain and found the following:

  Longitudinal EMG studies demonstrated that subluxation developed during the flaccid period and not occur after the supraspinatus muscle demonstrated EMG activity in response to loading.

  Early facilitation of activity in muscle groups producing protraction and upward rotation of the scapula and flexion/abduction of the shoulder is essential.

  Electrical stimulation of the supraspinatus and deltoid muscle can be used for maintaining the alignment of the glenohumeral joint and has been recommended as an effective substitute for a sling.[48]

- ✓ **Faghri P.D., et al (1994):** 26 recent hemiplegic stroke patients with shoulder muscle flaccidity are randomly assigned to either control or experimental group. Both groups received conventional physical therapy. The experimental group received functional electrical stimulation (supraspinatus and posterior deltoid) repetitively upto 6 hrs a day for 6 weeks. The experimental group showed significant improvement in arm function, EMG activity of the posterior deltoid, ROM, and reduction in subluxation compared to control group.[35]

- ✓ **Kobayashi H, (1999):** FES is used to treat glenohumeral subluxation from a stroke on the basis of two main effects: (1) muscle conditioning and (2) increase of muscle force and voluntary control ability.[49]
- ✓ **Chantraine A et al., (1999),** a controlled a study with 120 hemiplegic patients. The subjects are alternately assigned to control or experimental group, who received functional electrical stimulation (FES) for 5 weeks on muscles surrounding their subluxed and painful shoulder. The FES group showed more improvement than the control group in pain relief and reduction of subluxation and possibly have facilitated recovery of the shoulder function.[21]
- ✓ **Sandra L. Linn et al., (1999),** a randomized controlled study with 40 hemiplegic patients (age range from 45 to 84 years) and are randomly assigned to control or treatment group. They are assessed within 48 hours of their stroke, and those in the treatment group are immediately put on a regimen of electrical stimulation 4 times each day for 4 weeks. The electrodes are positioned to stimulate supraspinatus and posterior deltoid muscles. The control group demonstrated greater subluxation than the

treatment group, but the effect of the electrical stimulation was not maintained after the withdrawal of treatment.[55]

- ✓ **Price C.I. and Pandyan A.D. (2001)** did a systemic Cochrane review of 4 trials (total of 170 subjects) of electrical stimulation for post stroke shoulder pain and concluded that the electrical stimulation reduced the severity of glenohumeral subluxation, but there was no significant effect on upper limb motor recovery or upper limb spasticity.[73]

- ✓ **Yu et al. (2001),** in this study 8 patients participated in six weeks of percutaneous intramuscular electric stimulation (per-NMES). At end of treatment, there was a significant improvement of shoulder subluxation, pain, shoulder pain-free rotation and in Functional Impairment Measure (FIM) scores.[104]

- ✓ **Ada L, Foongchomcheay A (2002),** in a meta – analysis of 7 clinical trials concluded when electrical stimulation is added to conventional physical therapy, it prevented an average 6.5mm of shoulder subluxation, but only reduced by 1.9mm compared with conventional therapy alone

  Thus, this supports the use of electrical stimulation early after stroke for the prevention of, but not late after stroke for the reduction of shoulder subluxation.[1]

- ✓ **Chae J, Yu D (2000) and de Kroon JR (2002)** said that the conventional neuromuscular electrical stimulation (NMES) does not produce functional changes, because patients do not volitionally activate their muscles (ie, participation is passive) and do not practice functional activities.[19]

- ✓ **P Taylor (2002):** The deltoid is easy to stimulate as it is the most superficial muscle but it is useful to target supraspinatus because of its central role in locating the humeral head. Hence during electrical stimulation the electrodes must be placed over supraspinatus and posterior deltoid with an aim of preventing or reducing the hemiplegic shoulder subluxation.[74]

- ✓ **Cisari C, Carda S. (2002):** Muscles that are usually treated are the supraspinatus and the posterior deltoid muscle because they play a fundamental role in maintaining correct alignment of the glenohumeral joint.[25]

- ✓ **Koji Shomoto and Tomoaki Shimada (2003):** in his study he took 44 patients with hemiplegia. The experimental group (22 subjects) received conventional therapy and n neuromuscular electrical stimulation (NMES) for 6-7 weeks. After this regime, 8 patients are treated for 1-2 weeks by conventional physical therapy alone. The control group after finishing their conventional physical therapy sessions, 5 patients in the control group are given additional NMES. NMES treatment is total of 5 hours per day, 5 days per week; one electrode was placed over the motor point of supraspinatus muscle and the other was placed over the insertion of the supraspinatus muscle; another two electrodes are placed over the motor point and the origin of the posterior deltoid muscle. All patients in experimental group showed a significant subluxation after the NMES withdrawal and the 5 patients in the control group, who received NMES revealed a significant improvement in shoulder subluxation.[50]

- ✓ **John Chae et al., (2005),** a single – blinded, randomized controlled study with 61 chronic stroke patients with shoulder pain and subluxation. Treatmant subjects received intramuscular electrical stimulation to the supraspinatus, posterior deltoid, middle deltoid, and upper trapezius for 6 hrs per day for 6 weeeks. The control group are treated with a cuff – type sling for 6 weeks. Intramuscular electrical stimulation significantly reduces hemiplegic shoulder pain and the effect is maintained for >/=12 months post treatment.

  In the secondary analysis of this study (2007) found that stroke survivors who are treated with early after stroke onset may experience greater benefit from intramuscular electrical stimulation for post stroke shoulder pain.[47]

- ✓ **Dong Y (2007)** when repetitive, task – specific, paretic upper extremity practice is provided to hemiplegic stroke patients, the size of cortical areas representing that upper extremity can increase and correlative functional changes can be seen.[33]

- ✓ **Maarten J IJzerman et al., (2009),** in their review, they found that usually supraspinatus and posterior deltoid are stimulated as these muscles are important in realigning the glenohumeral joint and counteracting existing shoulder subluxation. The stimulation is applied temporarily between 4 weeks and 3 months duration.[57]

- ✓ **Rachael Lowe (2010),** in his study with total of 50 hemiplegic patients with shoulder subluxation and shoulder pain All patients are put on a rehabilitation program using conventional methods while the study group patients are additionally applied functional electrical stimulation(FES) to supraspinatus and posterior deltoid muscles. The results of this study have shown that applying FES treatment to the supraspinatus and posterior deltoid muscles in addition to conventional treatment when treating the subluxation in hemiplegic patients is more beneficial than conventional treatment by itself.[76]

1.6. EMG analysis in hemiplegic shoulder:

- ✓ **Basmajian et al., (1959),** by using EMG and gross anatomic dissection, found that downward dislocation of the humerus, following loading is prevented by contraction of the supraspinatus and the posterior fibres of deltoid, in addition to tightening of the superior aspect of the shoulder capsule (coracohumeral ligament). This shows that in a flaccid hemiplegic shoulder, the shoulder joint may remain permanently unstable as the supportive musculature and capsule are stretched by the dependant flaccid upper extremity.[6]

- ✓ **Chaco and Wolf (1971),** using EMG, studied relationship between hemiplegic shoulder subluxation and spasticity and flaccidity. They demonstrated the onset of subluxation within 3 weeks in flaccid patients, explained by the fact that the shoulder capsule holds the humeral head in place for a limited period of time and also said that unless spasticity with muscular activity appears, subluxation can no longer be prevented by the capsule alone.

  In his study 17 patients are divided into 3 groups; 2 groups are given therapeutical electrical stimulation for 6 weeks, 15 minutes twice a day; third group was a control group. The muscles stimulated are supraspinatus and posterior deltoid. The interference pattern of EMG at maximal voluntary contraction increased and the amplitude of the stimulated muscles are also increased. Thus, they concluded from their study that electrical stimulation therapy of the supraspinatus and the posterior deltoid are an effective treatment modality for shoulder subluxation and shoulder function in hemiplegia.[19]

- ✓ **Judy W. Griffin (1986),** Longitudinal EMG studies demonstrated that subluxation developed during the flaccid period and not occur after the supraspinatus muscle demonstrated EMG activity in response to loading.[48]

1.7. Outcome measures:

- ✓ **Boyd and Torrance, (1992)** palpation has shown to have higher reliability and validity as compared with other clinical methods.[9]
- ✓ **K. Shomoto et al., (2003),** said that the shoulder subluxation is usually detected when the patient begins to sit.[50]
- ✓ **P W Stratford, G F Spadoni (2001),** they did a study to estimate the measurement error associated with an 11-point numeric pain rating scale (NRS) with 124 patients and concluded that the 11-point pain numeric pain rating scale provides an efficient method of assessing pain intensity in clinical practice.[90]
- ✓ **Amelia Williamson, Barbara Hoggart (2005),** they reviewed three commonly used pain rating scales (visual analogue scale, verbal rating scale, and numeric rating scale) and concluded that all three pain-rating

scales are valid, reliable and appropriate for use in clinical practice, although the Visual Analogue Scale has more practical difficulties than the Verbal Rating Scale or the Numerical Rating Scale. For the general purpose, the Numerical Rating Scale has good sensitivity and generates data that can be statistically analysed for audit purposes.[101]

- ✓ **Rajaratnam BS et al.,(2007),** in his study about the clinical tests to identify shoulder pain after stroke gave the following conclusions:

  The confirm reports of an association between shoulder pain at rest after stroke and reduced external rotation in the affected shoulder and the onset is as early a week after stroke.

  Numerical pain rating scale is a valid and sensitive graded pain intensity scale that is simple to use and highly recommended for studies involving older patients.[77]

- ✓ **Malouin F et al., (1994),** He compared Fugl – Meyer Assessment (FMA) scale and Motor Assessment Sale (MAS). Thirty-two patients (with 20 men, 12 women) with a mean age of 60 years, and a mean time since stroke of 64.5 days, are tested with the FMA and MAS on two consecutive days. The results are (1) support the concurrent validity of the MAS for measuring motor recovery in acute stroke patients; (2) demonstrate the poor validity of the FMA sitting balance test, and (3) suggest that the FMA scale can better discriminate the level of motor recovery than the MAS in the early stage of recovery or in the more disabled subjects.[60]

- ✓ **Julie Sanford et al., (1993),** twelve patients **(7** male, 5 female): aged 49 to 86 years and are admitted consecutively to a rehabilitation center and are between 6 days and 6 months post stroke. 3 physical therapists, each with more than 10 years of experience, assessed the patients in a randomized and balanced order using Fugl – Meyer Assessment scale (FMA) and found that The overall reliability was high (overall intraclm correlation coefficient=.96), and the intraclm correlation coefficients for the subsections of the assessment variedjkm .61 for pain to .97 for the upper extremity.[85]
- ✓ **David J. Gladstone et al., (2002),** did a critical review regarding FMA and said that, "based on the available evidence the Fugl-Meyer motor scale is recommended highly as a clinical and research tool for evaluating changes in motor impairment following stroke.[27]
- ✓ **Meheroz H. Rabadi, MD, MRCPI, Freny M. Rabadi, BSc**., (2006), did a study with 104 subjects to assess the relative responsiveness the Action Research Arm Test (ARAT) and the Fugl-Meyer Assessment (FMA). They found high correlation between the ARAT and FMA, both on admission (ρ= .77, P< .001) and on discharge (ρ = .87, P<.001). They concluded that both can be used equally. [75]

2. AIM AND OBJECTIVES

3.1. AIM:

“To evaluate the effect of neuromuscular electrical stimulation (NMES) and motor activity eliciting exercises in preventing the occurrence of post stroke shoulder pain and subluxation and in enhancing early shoulder motor recovery in Brunnstrom’s stage I hemiplegic patients.

2.2. OBJECTIVES:

- To evaluate the effect of neuromuscular electrical stimulation (NMES) and motor activity eliciting exercises in preventing the occurrence of post stroke shoulder subluxation and pain in Brunnstrom’s stage I stroke patients.
- To compare the effect of neuromuscular electrical stimulation (NMES) and motor activity eliciting exercises with Bobath based exercises in preventing the occurrence of post stroke shoulder pain and improving shoulder motor function among Brunnstrom’s stage I stroke patients.
- To prevent occurrence of post stroke shoulder subluxation and pain.
- To elicit early motor activity in muscles around shoulder.

3. MATERIALS AND METHODOLOGY

4.1. STUDY DESIGN:

Pre test - post test Experimental study design.

3.2. STUDY POPULATION:

MCA hemiplegic subjects – Brunnstrom's stage I (complete flaccidity)

3.3. STUDY SETTING:

KMCH hospital, Coimbatore.

3.4. SAMPLE SIZE:

16 subjects

Group A: 8 patients under experimental group.

Group B: 8 patients under control group.

3.5. SAMPLING TECHNIQUES:

Subjects are selected by purposive sampling technique. They are divided randomly into control and experimental group.

3.6. SELECTION CRITERIA

3.6.1. INCLUSION CRITERIA:

- MCA stroke (both ischemic and haemorrhagic).
- Age between 40 and 80 years.

- Brunnstrom’s stage I patients for upper limb (shoulder), which indicates complete flaccidity.
- Patients within 2 weeks post stroke after being medically stable.
- Patients admitted within 48 hrs of stroke.
- Patient who can understand the commands and also can follow the given instructions.
- Line bisection test and star cancellation test should not be positive.

3.6.2. EXCLUSION CRITERIA:

- Patients with previous history of shoulder pathology and subluxation.
- Patients with current shoulder pain and subluxation.
- Patients with more than 2 weeks post stroke.
- Patients with severe heart disease and with pace maker.
- Patients with associated or with a history of any other neurological disorders.
- Patients who cannot able to perceive the nature of the innervations (current) and provide feedback about the treatment.
- Patients with impaired sensation and proprioception.

3.7. HYPOTHESIS:

3.7.1. NULL HYPOTHESIS

H_{01}: There is no significant post stroke shoulder pain with neuromuscular electrical stimulation (NMES) and motor activity eliciting exercises along with Bobath based exercises among Brunnstrom's stage I hemiplegic patients.

H_{02}: There is no significant improvement in post stroke shoulder motor function with neuromuscular electrical stimulation (NMES) and motor activity eliciting exercises along with Bobath based exercises among Brunnstrom's stage I hemiplegic patients.

H_{03}: There is no significant post stroke shoulder pain with Bobath based exercises alone among Brunnstrom's stage I hemiplegic patients.

H_{04}: There is no significant improvement in post stroke shoulder motor function with Bobath based exercises alone among Brunnstrom's stage I hemiplegic patients.

H_{05}: There is no significant difference between neuromuscular electrical stimulation (NMES) and motor activity eliciting exercises along with Bobath based exercises and Bobath based exercises alone in preventing post stroke shoulder pain among Brunnstrom's stage I hemiplegic patients.

H_{06}: There is no significant difference between neuromuscular electrical stimulation (NMES) and motor activity eliciting exercises along with Bobath based exercises and Bobath based exercises alone in improving shoulder motor function among Brunnstrom's stage I hemiplegic patients.

3.7.2. ALTERNATE HYPOTHESIS

H_{A1}: There is presence of significant post stroke shoulder pain with neuromuscular electrical stimulation (NMES) and motor activity eliciting exercises along with Bobath based exercises among Brunnstrom's stage I hemiplegic patients.

H_{A2}: There is a significant improvement in post stroke shoulder motor function with neuromuscular electrical stimulation (NMES) and motor activity eliciting exercises along with Bobath based exercises among Brunnstrom's stage I hemiplegic patients.

H_{A3}: There is presence of significant post stroke shoulder pain with Bobath based exercises alone among Brunnstrom's stage I hemiplegic patients.

H_{A4}: There is a significant improvement in post stroke shoulder motor function with Bobath based exercises among Brunnstrom's stage I hemiplegic patients.

H_{A5}: There is a significant difference between neuromuscular electrical stimulation (NMES) and motor activity eliciting exercises along with Bobath based exercises and Bobath based exercises alone in preventing post stroke shoulder pain among Brunnstrom's stage I hemiplegic patients.

H_{A6}: There is a significant difference between neuromuscular electrical stimulation (NMES) and motor activity eliciting exercises along with Bobath based exercises and Bobath based exercises alone in improving post stroke shoulder motor function preventing among Brunnstrom's stage I hemiplegic patients.

3.8. PROCEDURE:

Totally 16 patients, who provided informed consent and also fulfilled the study criteria are selected by purposive sampling technique, Out of those 16 subjects, 8 subjects are selected as control group and 8 subjects are selected as experimental group in an alternate manner.

In both groups, presence or absence of shoulder pain and subluxation, and motor function status for shoulder are assessed before and after the treatment program.

3.8.1. Control group:

Subjects under control group received only Bobath based exercises, which includes,

- Passive range of motion exercises for affected arm.
- Self- assisted over head shoulder movements.
- Weight bearing exercises to the affected arm in sitting with assistance.
- Proper handling techniques.
- Positioning.

3.8.2. Experimental group:

Subjects under experimental group received neuromuscular electrical stimulation (NMES) and motor activity eliciting exercises along with Bobath based exercises.

NEUROMUSCULAR ELECTRICAL STIMULATION (NMES)

The main aim of neuromuscular electrical stimulation was to prevent shoulder subluxation, in turn the shoulder pain.

PARAMETERS:

Type of current – Faradic current.

Pulse width – 1ms

Frequency – 40 - 50 Hz

Pulse amplitude – sufficient enough to achieve strength of contraction.

On/off period – 3sec on/6sec off

Session – 14 sessions; 1 hrs per day; 2 sessions per day; 5 days per week.

Electrodes used – 2 rubber electrodes.

Muscles – supraspinatus and posterior deltoid.

Fig.1.a. Picture showing the Electrical Stimulator used in the study.

PATIENT POSITION:

Subjects are made to sit in an arm chair with the affected arm supported with pillow; patients who are not able to sit are positioned in side lying over the unaffected side.

ELECTRODE PLACEMENT:

Active electrode – placed over the motor point of supraspinatus.

Inactive electrode – placed over the posterior deltoid.

Fig.1.b. Picture showing the placement of electrodes

(Active – supraspinatus; Inactive – posterior deltoid)

The skin was checked for erythema or any burns under the electrode placement daily after each treatment.

The patients are encouraged to perform the movement actively along with electrical stimulation.

MOTOR ACTIVITY ELICITING EXERCISES:

Carr and shepherd said,

- Even in an apparently flaccid arm, recovering motor activity can be found if therapist found muscle facilitation well enough to be able to search activity for and detects small amount of activity as soon as they occur.[16]
- First step in shoulder rehabilitation is to provide a means of exercise that enables the person to practice muscle activation and regain the ability to generate necessary force.[16]

The main aim of applying motor activity eliciting exercises was to promote shoulder function earlier.

Exercise program

After the electrical stimulation session, the following exercises are given initially with manual assistance. Verbal cues are given to actively participate in the session. After the recovery of volitional muscle contraction, gradually the patients are encouraged to perform actively.

1. **Supine lying / side lying**

The therapist lift the patient's arm & supports in forward flexion.

Task – attempt to reach up towards the ceiling.

Instructions

- "reach up towards the ceiling"
- "think about using your shoulder"
- "now let your shoulder go back to the be"

Checks

- Check for scapular movement;
- If no movement, it must be moved passively into position during the 1st few attempts;
- Don't allow the forearm to pronate / GH joint to internally rotate;
- Don't allow the retracting the shoulder actively – the return movement should involve eccentric muscle activity.

2. **Supine lying**

Patient is in relaxed supine lying position. Therapist is standing by the side & watching for muscular activity.

Task – attempt to lift the arm upward & sideward.

Instructions

- “try to lift your arm up”
- “try your bring your arm away from the body”
- “think about using your arm in lifting up & sideways”

3. **Supine lying**

Therapist lifts the patients arm & supports it in forward flexion.

Task - attempts parts to various tasks.

- To take the hand to head
- To take the hand above the head to the pillow

Instructions

- “see if you can take your hand down to your forehead- gently let your hand drop, now lift up little”
- “see if you can take your hand above your head to the pillow”

- “keep your arm in near your head, now try to reach above your head”.

4. **Sitting**

Patient sitting with affected arm supported by the table by the side; arm is kept in slight abduction & slight elbow flexion.

Task - To elevate the shoulder.

- To protract & retract shoulder.

Instructions

- “try to lift your shoulder up”
- “try to lift your elbow”
- “try to move your shoulder forward”
- “try to move your shoulder back”

5. **Sitting**

- Patient is seated at a table in front with both arms on top of the towel; the unaffected arm guiding the movement

Task - to polish the table

- To abduct & adduct the shoulder

Instructions

- “try to move your affected arm towards & away from the
- body sideways, guided by your unaffected arm”

Fig.2. Patient performing exercise in sitting

6. Sitting

The therapist holds the arm in slight abduction with 90^{o} flexion, maintain the wrist in slight extension.

Instructions

- "try to move your shoulder forward"
- "try to move your shoulder backward"
- "try to move your shoulder upward"
- "try to move your shoulder downward"
- "think about using your shoulder in each attempt of movement"

7. **Sitting**

Patient folds his hands together; the therapist holds the hands at the elbow with shoulder 90^0 flexion standing in from of the patient

Task – to protract & retract the scapula.

Instructions

- “try to move your shoulder forward”
- “try to move your shoulder backward”

3.9. TREATMENT DURATION:

14 sessions, one hour per session, two sessions a day of electrical stimulation and motor activity eliciting exercises along with Bobath based exercises.

3.10. OUTCOME MEASURES:

- Numeric pain rating scale (NRS) – shoulder pain
  - ℑ The numerical pain rating scale is a helpful tool that can be used to describe how much pain the patients are feeling and to measure how well treatments are relieving the pain.

- Fugl-Meyer motor assessment (FMA) scale – shoulder component:
    - The Fugl – Meyer Assessment scale (FMA) is a stroke specific, performance – based impairment index. It is designed to assess motor function in post – hemiplegic patients.
    - Developed by Fugl – Meyer, Jassko, Leyman, Olsson, and Stegling, 1975. It can be applied clinically and also in research to determine disease severity, describe motor recovery and to plan and to assess treatment. Suitable for acute and chronic patients and also can be applied to severely affected patients or patients with aphasia.
    - It takes about approximately 30-35 minutes to administer the total FMA. For the motor scale alone, it takes 20 minutes.
    - Duncan, Propst, and Nelson (1983) examined the **inter-rater** reliability and **test-retest reliability** of the FMA in 18 patients with chronic stroke. Inter-rater reliability was examined with 5 different therapists. Pearson correlations between therapists for each component of the FMA Motor domain upper extremity subscale were found to be excellent , ranging from r = 0.96 to r = 0.97. For the **test-retest reliability,** Motor domain upper extremity subscore was found to be excellent (r = 0.995 to r = 0.996).[91]

3.11. STATISTICAL ANALYSIS:

Pre-test and Post-test values of the study are collected and assessed for variation in improvement & their results are analyzed using Independent `t' test and Paired `t' test.

3.11.1. **Paired `t' test** (within groups)

$$t = \frac{\bar{d}\sqrt{n}}{S}$$

Where,

$$S = \sqrt{\frac{\sum d^2 - \left(\bar{d}\right)^2 \times n}{n-1}}$$

3.11.2. **Independent 't' test** (Between both the groups)

$$t = \frac{\bar{X}_1 - \bar{X}_2}{S}\sqrt{\frac{n_1 n_2}{(n_1+n_2)}}$$

Where,

$$S = \sqrt{\frac{\sum d_1^2 + \sum d_2^2}{n_1+n_2-2}}$$

S=combined standard deviation

d_1&d_2 =difference between initial & final readings in group A & group B respectively.

n_1&n_2=number of patients in group A & group B respectively.

$\bar{X}_1$&$\bar{X}_2$ =Mean of group A & group B respectively.

4. DATA ANALYSIS AND RESULTS

5.1. DEMOGRAPHIC DATA

		CONTROL GROUP	EXPERIMENTAL GROUP
SEX [no. of subjects %]	Male	7 (87.5%)	4 (50%)
	Female	1 (12.5%)	4 (50%)
AGE (years) [mean ± SD]	Male	57.42 ± 12.82	56 ± 8.8
	Female	1	55.5 ± 13.88
TYPE OF STROKE [no. of subjects %]	Infarction	4 (50%)	2 (25%)
	Haemorrhage	4 (50%)	6 (75%)
WEAKNESS SIDE [no. of subjects %]	Left	6 (75%)	5 (62.5%)
	Right	2 (25%)	3 (37.5%)
DURATION		8.375 ± 4.12	5.37 ± 2.91

[mean ± SD]			

5.2. TABULAR PRESENTATION

Table: 5.2.1: Paired ‘t’ test value for Numerical Pain Rating Scale among control group.

	Pre – test	Post – test
Mean ± SD	0	1.875 ±1.535
Mean difference	1.875	
Calculated ‘t’ value	3.233	
P value and level of significance	P < 0.05 and significant	

The pre – test and post – test values of numerical pain rating scale in control group is analyzed by paired‘t’ test for the presence of post stroke shoulder pain. The table‘t’ value at the level of 5 % significance and for 7 degrees of freedom is 1.895 and the calculated ‘t’ value is 3.233. As the calculated value is greater than the table‘t’ value, the null hypothesis is rejected. Hence there is a presence of significant post stroke shoulder pain with Bobath based exercises alone among Brunnstrom's stage I hemiplegic patients.

Table: 5.2.2: Paired 't' test value for Numerical Pain Rating Scale among experimental group.

	Pre – test	Post – test
Mean ± SD	0	0.5 ± 1.414
Mean difference	0.5	
Calculated 't' value	1.88	
P value and level of significance	P > 0.05 and not significant	

The pre – test and post – test values of Numerical pain rating scale in experimental group is analyzed by paired't' test for the presence of post stroke shoulder pain. The table't' value at the level of 5 % significance and for 7 degrees of freedom is 1.895 and the calculated 't' value is 1.88. As the calculated value is lesser than the table't' value, the null hypothesis is accepted. Hence, there is no significant post stroke shoulder pain with neuromuscular electrical stimulation (NMES) and motor activity eliciting exercises along with Bobath based exercises among Brunnstrom's stage I hemiplegic patients.

Table: 5.2.3: paired 't' test value for Fugl – Meyer Assessment scale among control group.

	Pre – test	Post – test
Mean ± SD	3 ± 1.732	6 ± 1.581
Mean difference	3	
Calculated 't' value	6.47	
P value and the level of significance	P < 0.05 and significant	

The pre – test and post – test values Fugl – Meyer assessment scale (shoulder component) in control group is analyzed by paired't' test for the post stroke shoulder motor function. The table't' value at the level of 5 % significance and for 7 degrees of freedom is 1.895 and the calculated 't' value is 6.47. As the calculated value is greater than the table't' value, the null hypothesis is rejected. Hence, there is a significant improvement in post stroke shoulder motor function with

Bobath based exercises among Brunnstrom’s stage I hemiplegic patients.

Table: 5.2.4: paired ‘t’ test value for Fugl – Meyer Assessment scale among experimental group.

	Pre – test	Post – test
Mean ± SD	3 ± 1.732	12.125 ± 9.39
Mean difference	9.125	
Calculated ‘t’ value	7.89	
P value and the level of significance	P < 0.05 and significant	

The pre – test and post – test values of Fugl – meyer assessment (FMA) scale (upper limb component) in experimental group is analyzed by paired‘t’ test for the post stroke shoulder motor function. The table‘t’ value at the level of 5 % significance and for 7 degrees of freedom is 1.895 and the calculated ‘t’ value is 7.89. As the calculated value is greater than the table‘t’ value, the null hypothesis is accepted. Hence, There is a significant improvement in post stroke shoulder motor function with neuromuscular electrical stimulation (NMES) and motor activity eliciting exercises along with Bobath based exercises among Brunnstrom’s stage I hemiplegic patients.

Table: 5.2.5: Independent ‘t’ test value of pre – test for Numerical Pain Rating scale between experimental and control group.

	Experimental group	Control group
Mean	0	0
Mean difference	0	
Calculated ‘t’ value	0	
P value and the level of significance	P > 0.05 and not significant	

The pre – test values of Numerical pain rating scale (NRS) are compared between the experimental group and the control group by using independent‘t’ test. The table‘t’ value at 5 % level of significance for 14 degrees of freedom is 1.761 and the calculated ‘t’ value is 0. As the calculated‘t’ value is less than the table‘t’ value, there is no significant difference between the experimental and the control group in the pre – test values of post stroke shoulder pain among Brunnstrom’s stage I hemiplegic patients.

Table: 5.2.6: Independent ‘t’ test value of post – test for Numerical Pain Rating scale between experimental and control group.

	Experimental group	Control group
Mean ± SD	0.5 ± 1.414	1.875 ± 1.535
Mean difference	1.375	
Calculated ‘t’ value	2.157	
P value and the level of significance	P < 0.05 and significant	

The post – test values of Numerical pain rating scale (NRS) are compared between the experimental group and the control group by using independent‘t’ test. The table‘t’ value at 5 % level of significance for 14 degrees of freedom is 1.761 and the calculated ‘t’ value `is 2.157. As the calculated‘t’ value is greater than the table ‘t’ value, the null hypothesis is rejected. Hence, There is a significant difference between neuromuscular electrical stimulation (NMES) and motor activity eliciting exercises along with Bobath based exercises and Bobath based exercises alone in preventing post stroke shoulder pain` among Brunnstrom's stage I hemiplegic patients.

Table: 5.2.7: Independent 't' test value of pre – test for Fugl – Meyer Assessment scale between experimental and control group.

	Experimental group	Control group
Mean ± SD	3 ± 1.732	3 ± 1.732
Mean difference	0	
Calculated 't' value	0	
P value and the level of significance	P > 0.05 and significant	

The pre – test values of Fugl – Meyer assessment (FMA) scale are compared between the experimental group and the control group by using independent't' test. The table't' value at 5 % level of significance for 14 degrees of freedom is 1.761 and the calculated 't' value is 0. As the calculated't' value is less than the table 't' value, there is no significant difference between the experimental and the control group in the pre – test values of post stroke shoulder motor function.

Table: 5.2.8: Independent ‘t’ test value of post – test for Fugl – Meyer Assessment scale between experimental and control group.

	Experimental group	Control group
Mean ± SD	12.125 ± 9.39	6 ± 1.581
Mean difference	6.125	
Calculated ‘t’ value	4.04	
P value and the level of significance	P < 0.05 and significant	

The post – test values of Fugl – Meyer assessment (FMA) scale (shoulder component) are compared between the experimental group and the control group by using independent‘t’ test. The table‘t’ value at 5 % level of significance for 14 degrees of freedom is 1.761 and the calculated‘t’ value is 4.04. As the calculated‘t’ value is greater than the table‘t’ value, the null hypothesis is rejected. Hence, There is a significant difference between neuromuscular electrical stimulation (NMES) and motor activity eliciting exercises along with Bobath based exercises and Bobath based exercises alone in preventing post stroke shoulder pain among Brunnstrom's stage I hemiplegic patients.

5.3. GRAPHICAL REPRESENTATION

Fig.5.3.1: Graphical representation of mean values for numerical pain rating scale (NRS) among control group.

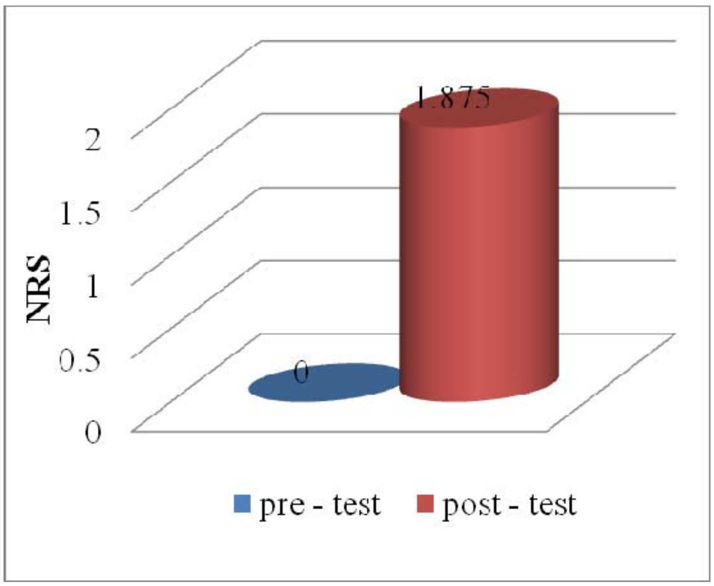


Fig.5.3.2: Graphical representation of mean values for numeric pain rating scale (NRS) among experimental group.

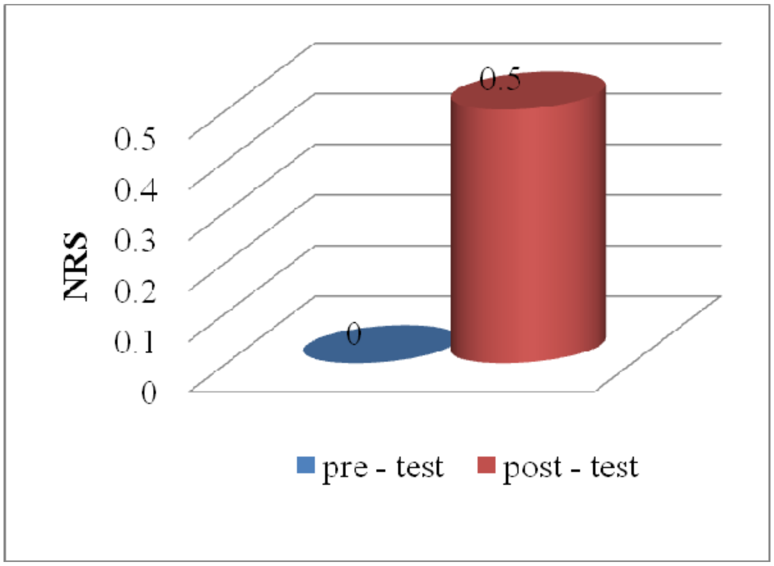


Fig.5.3.3: Graphical representation of mean values for Fugl – Meyer Assessment scale (FMA) among control group.

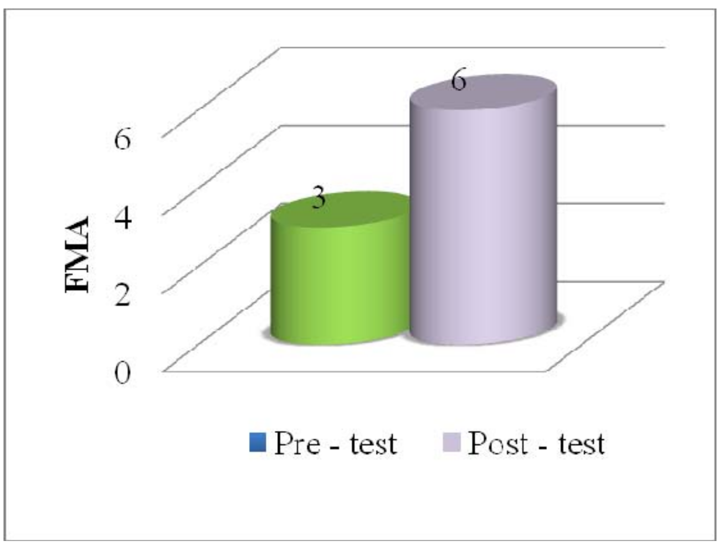


Fig.5.3.4: Graphical representation of mean values for Fugl – Meyer Assessment scale (FMA) among experimental group.

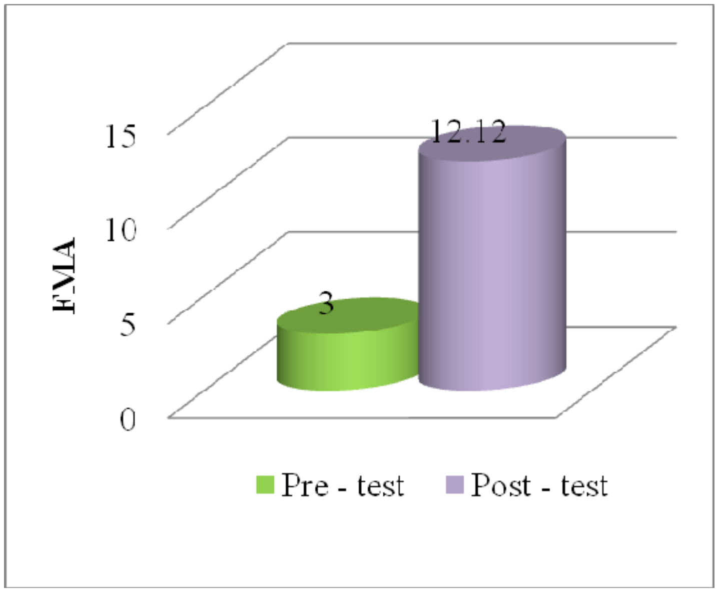


Fig.5.3.5: Graphical representation of mean values for Numerical pain rating scale (NRS) among experimental and control group.

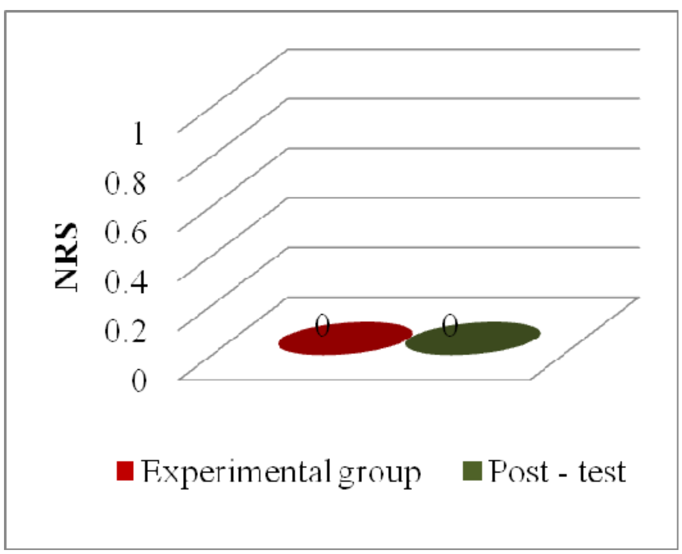


Fig.5.3.6: Graphical representation of mean values for numerical pain rating scale (NRS) among experimental and control group.

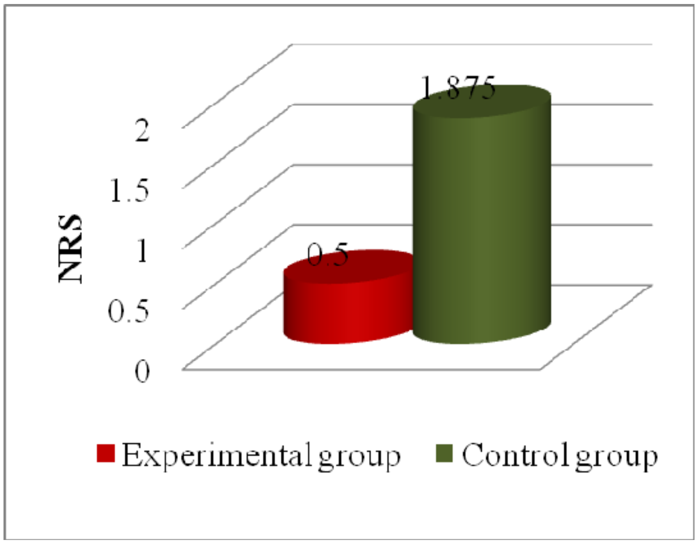


Fig.5.3.7: Graphical representation of mean values for Fugl – Meyer Assessment (FMA) scale among experimental and control group.

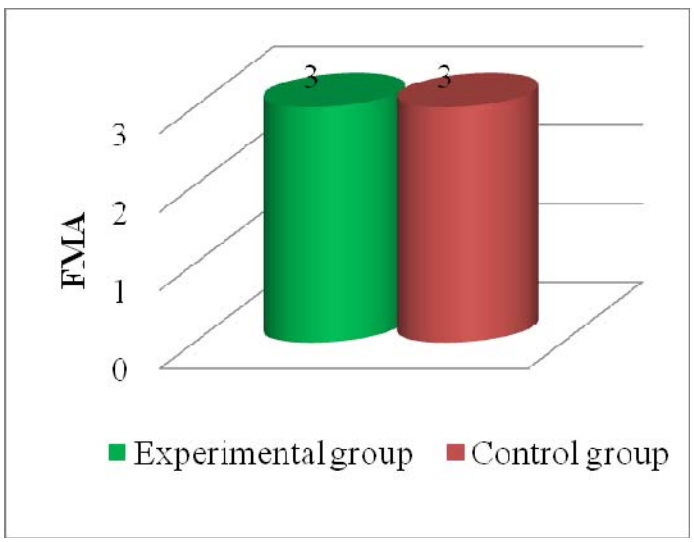
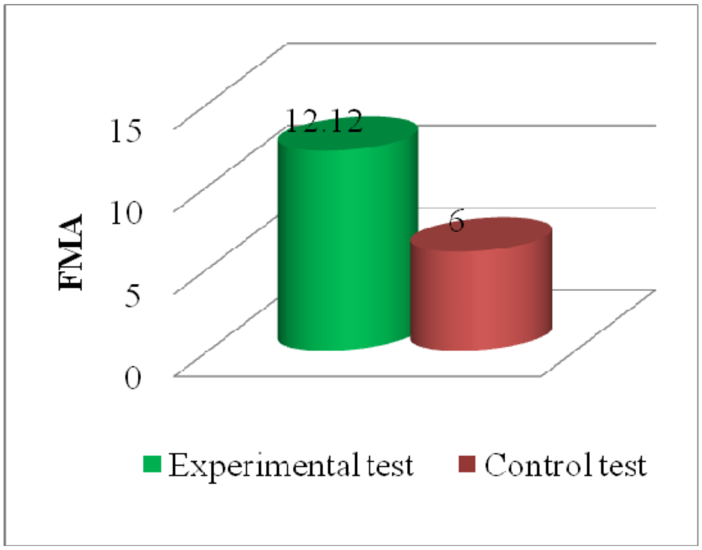


Fig.5.3.8: Graphical representations of mean values for Fugl – Meyer Assessment (FMA) scale among experimental and control group.



5.4. RESULTS

5.4.1. TABULAR INTERPRETATION

Paired 't' test for Numerical Pain Rating Scale among control group:

As shown in table.5.2.1, The pre – test and post – test values of numerical pain rating scale among control group is analyzed by paired't' test for post stroke shoulder pain. The table't' value at the level of 5 % significance and for 7 degrees of freedom is 1.895 and the calculated 't' value is 3.233. As the calculated value is greater than the table't' value, the null hypothesis is rejected. Hence there is a significant post stroke shoulder pain with Bobath based exercises alone among Brunnstrom's stage I hemiplegic patients.

Paired 't' test for Numerical Pain Rating Scale among experimental group:

As shown in table.5.2.2, the pre – test and post – test values of Numerical pain rating scale in experimental group is analyzed by paired't' test for the presence of post stroke shoulder pain. The table't' value at the level of 5 % significance and for 7 degrees of freedom is 1.895 and the calculated ‘t’ value is 1.88. As the calculated value is lesser than the table‘t’ value, the null hypothesis is accepted. Hence, there is no significant post stroke shoulder pain with neuromuscular electrical stimulation (NMES) and motor activity eliciting exercises along with Bobath based exercises among Brunnstrom’s stage I hemiplegic patients.

Paired ‘t’ test for Fugl – Meyer Assessment scale among control group:

As shown in table.5.2.3, The pre – test and post – test values of Fugl – Meyer assessment scale (shoulder component) in control group is analyzed by paired‘t’ test for the post stroke shoulder motor function. The table‘t’ value at the level of 5 % significance and for 7 degrees of freedom is 1.895 and the calculated ‘t’ value is 6.47. As the calculated value is greater than the table‘t’ value, the null hypothesis is rejected. Hence, there is a significant improvement in post stroke shoulder motor function with Bobath based exercises among Brunnstrom’s stage I hemiplegic patients.

Paired ‘t’ test for Fugl – Meyer Assessment scale among experimental group:

As shown in table.5.2.4, The pre – test and post – test values of Fugl – meyer assessment (FMA) scale (upper limb component) in experimental group is analyzed by paired‘t’ test for the post stroke shoulder motor function. The table‘t’ value at the level of 5 % significance and for 7 degrees of freedom is 1.895 and the calculated ‘t’ value is 7.89. As the calculated value is greater than the table‘t’ value, the null hypothesis is accepted. Hence, There is a significant improvement in post stroke shoulder motor function with neuromuscular electrical stimulation (NMES) and motor activity eliciting exercises along with Bobath based exercises among Brunnstrom’s stage I hemiplegic patients.

Independent ‘t’ test of pre – test values for numerical pain rating scale between experimental and control group:

As shown in table.5.2.5, The pre – test values of Numerical pain rating scale (NRS) are compared between the experimental group and the control group by using independent‘t’ test. The table‘t’ value at 5 % level of significance for 14 degrees of freedom is 1.761 and the calculated ‘t’ value is 0. As the calculated‘t’ value is less than the table‘t’ value, there is no significant difference between the experimental and the control group in the pre – test values of post stroke shoulder pain among Brunnstrom’s stage I hemiplegic patients.

Independent ‘t’ test for post – test values of Numerical Pain Rating Scale between experimental and control group:

As shown in table.5.2.6, The post – test values of Numerical pain rating scale (NRS) are compared between the experimental group and the control group by using independent‘t’ test. The table‘t’ value at 5 % level of significance for 14 degrees of freedom is 1.761 and the calculated 't' value is 2.157. As the calculated't' value is greater than the table 't' value, the null hypothesis is rejected. Hence, There is a significant difference between neuromuscular electrical stimulation (NMES) and motor activity eliciting exercises along with Bobath based exercises and Bobath based exercises alone in preventing post stroke shoulder pain among Brunnstrom's stage I hemiplegic patients**.**

Independent 't' test for pre – test values of Fugl – Meyer Assessment scale between control and experimental group:

As shown in table.5.2.7, The pre – test values of Fugl – Meyer assessment (FMA) scale are compared between the experimental group and the control group by using independent't' test. The table't' value at 5 % level of significance for 14 degrees of freedom is 1.761 and the calculated 't' value is 0. As the calculated't' value is less than the table 't' value, there is no significant difference between the experimental and the control group in the pre – test values of post stroke shoulder motor function.

Independent 't' test for post – test values of Fugl – Meyer Assessment scale between experimental and control group:

As shown in table.5.2.8, The post – test values of Fugl – Meyer assessment (FMA) scale (shoulder component) are compared between the experimental group and the control group by using independent't' test. The table't' value at 5 % level of significance for 14 degrees of freedom is 1.761 and the calculated't' value is 4.04. As the calculated‘t’ value is greater than the table‘t’ value, the null hypothesis is rejected. Hence, There is a significant difference between neuromuscular electrical stimulation (NMES) and motor activity eliciting exercises along with Bobath based exercises and Bobath based exercises alone in preventing post stroke shoulder pain among Brunnstrom’s stage I hemiplegic patients.

6. DISCUSSION

The shoulder pain is the most common complication with hemiplegia and found to hinder the rehabilitation as the painful joint may mask the improvement in motor function. Shoulder subluxation is found to be the contributing factor in the development of hemiplegic shoulder pain. This study is done with an aim of preventing the occurrence of post stroke shoulder pain and subluxation in acute stage.[70]

Chaco and Wolf demonstrated that subluxation seems to occur in the first three weeks after stroke, while the limb is still flaccid, especially the supraspinatus muscle is inactive and also found that glenohumeral subluxation is the main contributing factor for post stroke shoulder pain.[18]

In the present study, significantly greater shoulder pain occurred in the control group than in the treatment group. the patients with shoulder pain are found to have shoulder subluxation which was measured subjectively by palpation,. Thus, glenohumeral subluxation could be the cause for the post stroke shoulder pain.

The prevalence of shoulder pain is found as 25% in experimental group and 62.5% in control group. Reports of prevalence of shoulder pain in the literatures vary between 5 and 84%. It suggests that the application of neuromuscular electrical stimulation prevented the occurrence of post stroke shoulder pain and subluxation.

The result of the study is consistent with previous similar studies. **Ada L. And Foongchomcheay A. (2002)**, in the meta - analysis found that electrical stimulation added to conventional physical therapy prevented shoulder subluxation when applied early after stroke but not later.[1]

The electrical stimulation might have helped to facilitate the flaccid shoulder muscles and preserve the muscles strength, thereby gives the benefit of reduced shoulder pain and promote motor recovery due to better alignment of shoulder joint. And also electrical stimulation might have increased proprioceptive stimulation and repetitive movements induced by surface neuromuscular stimulation could have helped in motor relearning.[1, 21, 99, 81]

The results of this study also showed significantly greater improvement in Fugl – Meyer Assessment (Shoulder motor function) score, when motor activity eliciting exercises are added to electrical stimulation when compared to control group. It can be assumed that early practice of relevant motor tasks takes advantage of the brain’s plasticity. Studies suggested that patients on a specific programme of motor learning, which should start with in first few days after stroke, make a more impressive recovery of function with less reflex hyperactivity. This may be due to the emphasis both on very early training of context – specific control of muscles of the affected limbs, and prevention of muscle contractures and length – associated changes, as well as on elimination of overuse of the intact side and unnecessary muscle activity of the affected side.[16]

It was also told that neuromuscular electrical stimulation alone does not produce functional changes, as patients do not volitionally activate their muscles. When repetitive, task – specific practice is provided, the size of the cortical areas representing that treatment part can increase and correlative functional changes can be seen.[92]

Thus, motor activity eliciting exercise programme must be added to neuromuscular electrical stimulation to facilitate early shoulder mobility.

Patients in control group developed pain and subluxation with in two weeks post stroke. Hence, electrical stimulation along with shoulder exercises should be started immediately after stroke to preserve shoulder motor function.

7. SUMMARY AND CONCLUSION

This present study showed that electrical stimulation applied early after stroke prevent the occurrence of post stroke shoulder pain and subluxation, which is found by numerical pain rating scale (NRS). And also the result showed significantly greater improvement with Fugl – Meyer Assessment score (shoulder component) in experimental group than the control group. Thus, motor – activity eliciting exercise programme when added to electrical stimulation enhances early shoulder mobility among acute hemiplegic patients.

8. LIMITATIONS AND SUGGESTIONS

LIMITATIONS:

1. Smaller sample size (n =16).
2. Ideal outcome measure to quantify shoulder subluxation was not feasible in our settings.
3. Follow up was not done.
4. Apart from the study intervention, the patients also received occupational therapy and physical therapy, which cannot be controlled.

SUGGESTIONS:

1. Experiment should be started as early as possible.
2. EMG analysis can be done to note the muscle activity.
3. Follow up should be done to know the long term effects.

4. Difference in the improvement can be seen between ischemic and haemorrhagic type and also in different stages of upper limb voluntary contraction.
5. Neuromuscular electrical stimulation can also be used as EMG biofeedback in enhancing muscular activity in post stroke shoulder.

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APPENDIX I

INFORMED CONSENT TO PARTICIPATE IN THE RESEARCH STUDY

I _____________ voluntarily consent to participate in the research study, **“EFFECT OF NEUROMUSCULAR ELECTRICAL STIMULATION AND MOTOR ACTIVITY ELICITING EXERCISES IN EARLY SHOULDER REHABILITATION AMONG BRUNNSTROM’S STAGE I HEMIPLEGIC PATIENTS**”.

The researcher has explained to me about the research in brief, the risk of participation and has answered the questions related to the research to my satisfaction.

Signature of the subject: **Signature of the researcher:**

Signature of the witness:

APPENDIX II

DATA PERFORMA

Name :

Age / sex :

Doctor referred :

Type of stroke :

Side affected :

Duration :

Aphasia :

Sensation :

Proprioception :

Group :

OUTCOME MEASURES:

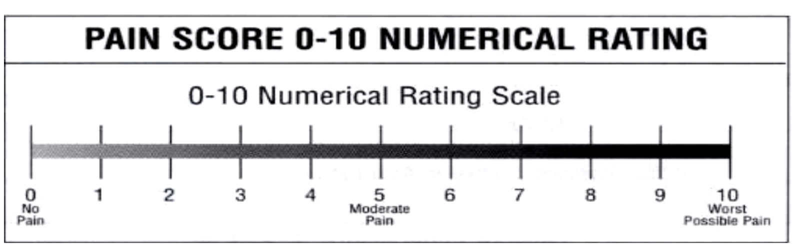
MEASURES	PRE – TEST	POST – TEST
Numerical pain rating		

scale (NRS)		
Fugl – Meyer Assessment scale (FMA)		

APPENDIX III

NUMERICAL PAIN RATING SCALE

- It is an 11 point scale ranging from 0-10, in which o refers to no pain & 10 refers to worst pain experienced
- This approach to measuring pain intensity provides an ordered numeric ranking of pain intensity experience, using an intuitive whole number scale (0-10).
- It is assumed that the level of pain experienced is abnormal for the patient, and is therefore memorable for them.



APPENDIX IV

THE FUGL-MAYER ASSESSMENT (FMA) PHYSICAL PERFORMANCE

AREA	**TEST**	**MAXIMUM POSSIBLE SCORE**	**ATTAINED SCORE**
UPPER EXTREMITY (SITTING)	Motor I. Reflexes a. Biceps b. Triceps	4	
	II. Flexor synergy - Elevation - Shoulder retraction - Abduction (at least 90°) - Elbow flexion - Forearm supination	12	

	III. Extensor synergy - Shoulder abduction/internal rotation - Elbow extension - Forearm pronation	6	
	IV. Movement combining synergies a. Hand to lumbar spine b. Shoulder flexion to 90° Elbow at 0° - Pronation/supination of forearm with elbow at 90° and shoulder at 0°	6	
	V. Movement out of synergy a. Shoulder abduction to 90° elbow at 0° and forearm pronated b. Shoulder flexion, 90-180° elbow at 0° and forearm in mid position c. Pronation/supination of forearm elbow at 0° and shoulder between 30-90° of flexion	6	

TOTAL SCORE: 34

Scoring Criteria

0- Cannot be performed at all.

1- Performed partly.

2- Performed faultlessly.